

MODULE 5

SYSTEM ARCHITECTURE

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REVISION HISTORY

QRC	P/N-REVISION	INITIATOR	APPROVAL	DATE	CHANGE
			S. Williams	July 1999	Incorporate reviewer comments
A3210	59155 Rev. 1	J. Madarasz	S. Williams	Dec. 2000	Initial Release

OVERVIEW

OBJECTIVE

To explain the signal paths for different the Sequoia system ultrasound modalities and board functions, in order for Customer Engineers, International Distributors and BioMed Engineers to troubleshoot a Sequoia system problem.

PURPOSE

Troubleshooting a Sequoia system at a customer site can be a demanding task. Most of the time, isolating the cause of a failure is an easy task using the state-of-the-art service diagnostic software. However, occasionally the failure symptom must be related to the function of a specific board. Following the signal path for the modality can also be a useful tool in such a situation.

INSTRUCTIONS

- 1** Listen to the presentation.
 - 2** Read the module.
 - 3** Answer the questions in the worksheet provided at the end of the module.
-

SYSTEM ARCHITECTURE

SYSTEM CHASSIS

The Sequoia system consists of a card cage with a capacity for up to 15 printed circuit boards (PCB), plus the backplane. Access to the PCBs is available by removing the right side cover and removing the shielding cover from the card cage.

CAUTION!

The Sequoia system contains numerous devices sensitive to electrostatic discharge (ESD). Failure to observe strict ESD prevention procedures may damage components. Access to internal assemblies is restricted to Acuson trained service personnel only.

Transducers are plugged directly into the system via the MX board. Depending on the system configuration, up to three 128-element transducers or one 256-element transducer and two 128-element transducers may be connected at one time. The right transducer connector only supports a 256-element transducer on the Sequoia 512 system.

The DC power is supplied to the chassis from a single power supply located at the rear of the chassis, behind the service access cover. Power connections to the printed circuit boards are made via the backplane of the card cage. See the *Following Power Distribution* module for more detail.

WARNING!

Voltages present within the Sequoia system are capable of causing injury or death. Access to internal assemblies is restricted to Acuson trained service personnel.

BASIC SYSTEM ARCHITECTURE

Sequoia system technology represents the most fundamental and far-reaching advance in ultrasound technology since the advent of Computed Sonography in 1983. It incorporates four foundation technologies that produce dramatic image quality, performance, and functionality improvements in all modes of operation. The system architecture can be divided into three major subsystems:

- Coherent Imageformer
- DIMAQ workstation
- Power Subsystem

Figure 5-1 illustrates the basic Sequoia system architecture.

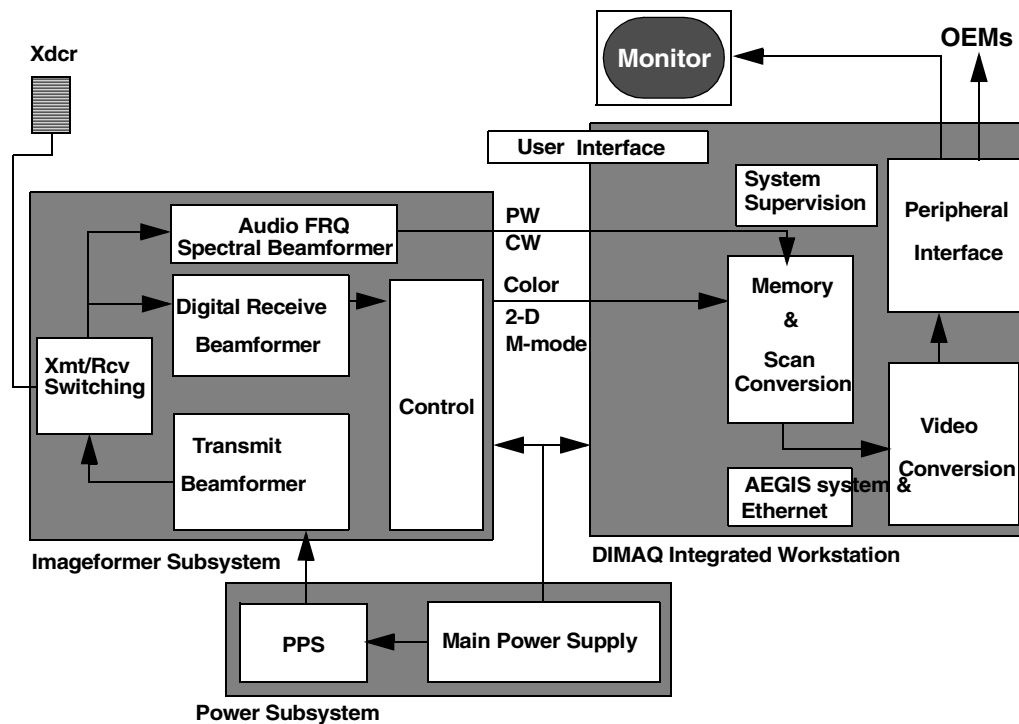


Figure 5-1 Basic System Architecture of Sequoia System

COHERENT IMAGEFORMER

COHERENT IMAGEFORMER

The Coherent Imageformer subsystem performs three primary functions. These are:

- Transmission of focused ultrasound energy
- Receive and process of back scattered ultrasound energy
- Control of transmit and receive parameters to sweep the ultrasound beams through the field of view

The Coherent Imageformer performs these functions by setting the phase and amplitude parameters for each transmit / receive element in the transducer. Sophisticated computer control of these parameters provides extensive flexibility in controlling the transmitted ultrasound beam and processing the back-scattered energy picked up by each transducer element.

MULTIPLE BEAMFORMATION

The Multiple Beamformer is a new beamformer architecture that utilizes up to 512 digital processing channels. This unique architecture:

- Processes phase and amplitude
- Acquires multiple beams simultaneously to capture information
- Acquires multiple beams in the same amount of time that a single beamformer acquires a single beam

The high-speed data acquisition generated by multiple beamformers translates directly into significantly higher frame rates, higher spatial resolution and increased sensitivity in 2-D and Color Doppler imaging modes.

Phase information is utilized by the Coherent Imageformer to acquire additional information that cannot be done without the use of phase.

COHERENT IMAGEFORMER PCBs

Five major board types make up the Coherent Imageformer. Each of these boards performs specific functions in the formation of an ultrasound image cell.

BOARD NAME	ACRONYM
Transmitter Board	TX
Multiplexer Board	MX
Receiver Board	RX
Beamformer Board	BF
Controller Board	CN

THEORY OF OPERATION

TRANSMISSION

All Coherent Imageformer functions are controlled by the Controller board (CN). Data regarding the type of ultrasound information to acquire, (e.g., 2-D mode, Color, Pulse Doppler, Depth of Scan, Power to use, etc.) are passed to the CN board on the system control bus.

The CN then passes parameter data to the transmitter boards on the Imageformer bus. In addition, configuration data is also passed to the Multiplexer (MX) and Receiver (RX) boards.

The Transmitter (TX) boards use this data to determine the pulse characteristics and time delay required. The digital pulse waveform is passed to a D/A converter, which creates the analog wave used to drive a high voltage amplifier. This amplifier output drives the transducer piezoelectric-crystal element. Two TX boards may be used to process a total of 512 digital processing channels. The high voltage pulses from the TX board are passed to the Multiplexer board (MX).

The MX board switches the transmit pulses to the appropriate transducer element, based upon the transducer(s) connected and the scan format used.

Each transducer consists of a number of piezoelectric-crystal elements. A piezoelectric-crystal element changes spatially when a voltage is applied across it. On receiving a high-frequency electric wave, the piezoelectric-crystal element vibrates and creates a high-frequency ultrasound wave.

The ultrasound wave propagates into the tissue of the patient being scanned. Wherever there is a change in the acoustic impedance, such as the interface between dissimilar tissues, a portion of the ultrasound wave is reflected. The magnitude of the reflected wave is a function of the difference in acoustic impedance between the tissues.

RECEPTION

Immediately after transmitting the ultrasound wave, the system begins acquiring echo data. A piezoelectric-crystal element not only changes geometry when a voltage is applied, it also creates an electric charge when the geometry of the element is mechanically changed. The ultrasound echo data returning from the patient excites the piezoelectric-crystal elements. The crystals output a small electric signal that is proportional to the amplitude of the received ultrasound waves.

The MX board routes these individual signals to the Receiver board (RX). The RX board provides initial amplification of the echo data. The signals are processed for gain and then passed to the Beamformer board (BF), where apodization occurs. The RX board also creates the clock signals used to synchronize system operations.

During spectral Doppler operation, the Doppler data is passed to the Spectral Doppler Preprocessor located on the RX board. The PW Doppler data is sampled only at the range gate. CW Doppler data is acquired from the entire sample line. The Doppler data is then processed and the quadrature data I&Q derived. The I&Q data are then digitized and placed on the RX I/Q data path for processing and display by the DIMAQ workstation.

The Beamformer board (BF) receives the back-scattered echoes from each receive channel. By processing echoes from numerous transducer arrays, the BF defines a series of coherently-focused image cells.

Two BF boards may be used to process four different ultrasound beams utilizing a total of 512 digital processing channels.

Figure 5-2 diagrams the Imageformer functions.

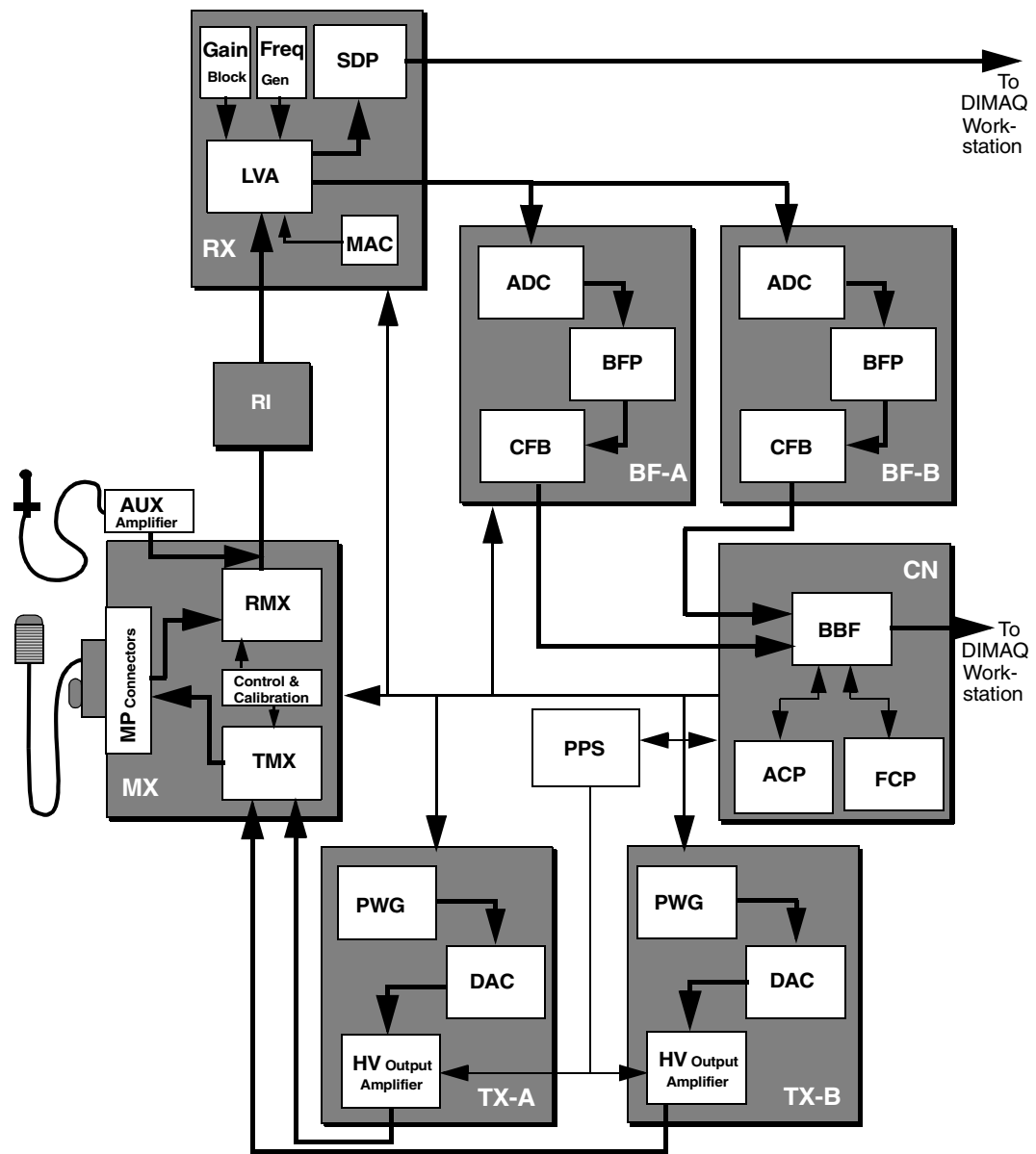


Figure 5-2 Imageformer Block Diagram

TRANSMITTER BOARD

TX3

Part Number TX2	35282
Part Number TX3	39142
Quantity	Cardiology: 1, Radiology: 2
Power Supplies	+5 VDC, +5.5 VDC, -5.7 VDC, ± 12 VDC; Vxmt
Signals In	TX Apodization, TX Delay
Signals Out	TX Signal (1-64)

FUNCTION

The Transmitter board (TX) provides the electrical signal used to drive the piezoelectric elements in the transducer. The TX is controlled by the Controller board (CN) via the IAB bus. Apodization and delay parameters are passed to the TX by separate signal lines.

The programmable wave generator (PWG) ASIC generates a digital transmit waveform for up to four beams.

The pulse parameters are specified for each transducer element based on the ultrasound line being fired. The parameters are converted to an analog signal, which is used to drive a high voltage amplifier. The high voltage amplifier uses the output from the Programmable Power Supply (PPS). The PPS is set by software to a given voltage based on the ultrasound line being fired. The high-voltage transmit pulses for each transducer element are then passed to the MX board.

TROUBLESHOOTING HINTS

Failures of the TX board are most likely to interrupt a single transmitter channel only. This is unlikely to be visually perceptible. If problems are suspected, replace the board to check for image improvement.

MULTIPLEXER BOARD

MX2/3

Part Number MX2	Cardiology: 39052, Radiology: 36262
Part Number MX3	Cardiology: 50642; Radiology: 39132
Quantity	One
Power Supplies	+5.5 VDC; ± 12 VDC; ± 100 V
Signals In	TX Signal (64 or 128 channels), TX Off, Control data
Signals Out	MX Signal (64 or 128 channels)

FUNCTION

The Multiplexer board (MX) provides the electrical connection between the Imageformer and the transducers supported by the Sequoia system.

The MX board has three functions:

- To switch the electrical transmit pulse from a selected transmitter channel to the appropriate transducer element.
- To switch the appropriate transducer element to the proper receive channel.
- Provide a signal path for calibration signals generated by a selected transmitter channel to be monitored by a selected receive channel.

The MX board is controlled by the Controller board (CN) via the MX/RX Bus. The CN configures the MX based upon the transducer(s) connected and selected.

TROUBLESHOOTING HINTS

Calibration signals may be passed from the Transmitter board (TX) to the Receiver board (RX) via the MX board. If a transmit or receive channel fails diagnostics and replacement of the board does not correct the problem, it is possible that the MX is not providing the necessary signal path.

RECEIVER BOARD

RX

Part Number RX2	Cardiology: 39052, Radiology: 32012
Part Number RX4	Cardiology: 51642; Radiology: 51562
Quantity	One
Power Supplies	+5.5 VDC; -5.7 VDC; ± 12 VDC
Signals In	MX Signal (64, or 128)
Signals Out	RX Signal, RX I/Q, Master System Clocks

FUNCTION

The Receiver board (RX) operates in two ways, depending upon the type of ultrasound data being processed. When a 2-D, F-mode or M-mode ultrasound line is being processed, the receive signal from MX for each channel is acquired and passes through circuitry that amplifies and preprocesses it. The signal is then passed to the Beamformer board (BF) for construction of an image cell.

When PW Doppler or CW Doppler data is being acquired, the data path is quite different. The Doppler data is amplified and preprocessed based on range gate position (PW), or acquired over the entire sample line (CW). The Doppler signals are then shifted temporally to create a coherent ultrasound image cell.

The temporally shifted Doppler data is summed and passed to the Color Spectral Doppler board (CSD) for conversion from time domain to the frequency domain.

The RX board also generates the master clock signals used by the system to synchronize operations.

TROUBLESHOOTING HINTS

The RX board is the point in the system where 2-D, F-mode, and M-mode signal processing diverge from PW Doppler and CW Doppler signal processing. For this reason, it is valuable to check each mode to see if symptoms that appear are present in each.

For instance, if a 2-D image has noise artifacts in one area of the image, then placing the PW Doppler cursor in that area provides an important troubleshooting clue. If the noise is present in both modes, then it is being introduced at RX board, or earlier in the processing path (e.g., RX, MX, TX, Power Supplies). If the noise is only in PW Doppler then it is being introduced in the RX board or later in the PW signal path (e.g., RX, CSD).

Failures of the RX board are most likely to interrupt a single signal path to/from the transducer. This is not visually perceptible. If problems are suspected, replace the board to check for image improvement.

Failure of the clocks causes the system to stop executing the boot sequence. The system display and boot appear “dead.”

RI BOARD

The Receiver Interconnect board or RI is located on top of the MX and RX boards in the cardcage. The main functions of this board are:

- Connects the signal from MX board to the RX board
- Passes clock signal to the MX board

Two versions of the RI boards are available. P / N 31992 is used on Sequoia 512 ultrasound systems, and P / N 35662 is used for Sequoia 256 echocardiography systems.

BEAMFORMER BOARD

BF3

Part Number	39152
Quantity	Cardiology: 1, Radiology: 2
Power Supplies	+5 VDC, +5.5 VDC, -5.7 VDC
Signals In	RX(0-63)
Signals Out	BF I / Q

FUNCTION

The Imageformer subsystem contains one Beamformer board (BF) in 256-channel systems and two BF boards in 512-channel systems. The BF performs digitizing of data from each receiver channel. This data is then processed by Acuson-developed proprietary BFP ASIC circuits. These ASICs perform the delay, apodization, phase adjust, and summation of the individual channels. The summed data is then mixed to convert it into a baseband signal (I&Q), which is then passed to the Controller board (CN). Systems with two BF boards have their outputs summed on the CN board.

Primary control and setup of the board for each ultrasound line is done by the Controller board (CN), over the IAB Control bus.

TROUBLESHOOTING HINTS

Failures of the beam formation process are generally perceived as one or more ultrasound lines being affected throughout the depth of the scan. The failure may be loss of data, noisy data, or other artifacts affecting a subset of the ultrasound lines throughout the depth of the scan.

On 512-channel systems, the location of the two BF boards can be switched, to see if the affected ultrasound lines move to a different part of the image area. If the artifact moves, the BF board is the defective assembly.

CONTROLLER BOARD

CN2/3

Part Number CN2	35822
Part Number CN3	39522
Quantity	One
Power Supplies	+5 VDC
Signals In	BF I/Q, PPS status
Signals Out	2-D, M Mode, F Mode data, PPS control

NOTE: CN3 is required for Sequoia Signature Option.

FUNCTION

The Controller board (CN) provides the overall control and timing for the Imageformer subsystem. It has an Acquisition Control Processor (ACP) that controls the Imageformer and interfaces with the DIMAQ workstation subsystem to ascertain the scan format (e.g., depth, focal zone, mode, gain vectors, etc.).

Based on the scan format, the CN determines the parameters required to configure each board in the Imageformer, as well as the CSD and BDM boards, to achieve the correct scan format. These parameters are passed to each board over the Acquisition Control bus.

The Focus Control Processor (FCP) generates transmit and receive apodization profiles. The CN also processes the ultrasound data from the BF board(s). When two BF boards are present in a system, the echo data is summed and gain-corrected by the CN.

F-mode data is then passed to the Color Spectral Doppler board (CSD), where the Color Doppler velocity data is derived from the ultrasound data. 2-D and M-mode data are passed to the 2-D mode / M-mode Processing and System Data Memory board (BDM) for preprocessing, temporal processing and storage.

TROUBLESHOOTING HINTS

Because the CN board controls the other boards in the Imageformer, failure of the CN could create a wide variety of imaging problems. In general, if an imaging problem cannot be resolved by replacing a suspected Imageformer board or boards, then replacing the CN would be recommended.

DIMAQ INTEGRATED ULTRASOUND WORKSTATION

The integration of a special purpose ultrasound workstation into the system architecture is at the heart of the Sequoia system's digital image management capabilities.

The DIMAQ workstation has numerous system capabilities which allow it to:

- Expand the science of quantification
- Expand Network and AEGIS system capability
- Perform JPEG compression, direct DICOM connectivity and display of multiple static and dynamic images
- Special applications, such as stress echo.

The primary function of the DIMAQ workstation is the display of data received from the Coherent Imageformer. Ultrasound data can be acquired in one of four formats, linear, sector, curved, or Vector Wide-View Array. None of these formats are similar to the video raster format, therefore a conversion process must take place in order to display the ultrasound data on a video monitor.

In addition to this, the DIMAQ workstation incorporates a number of other functions. These are to process ultrasound 2-D mode and Doppler data, to perform calculations, and to interface the system to various input and output devices including the user controls. Overall control of the system is the job of the System Supervisory Processor, which is located on the Reconstruction Display Processor board (RDP).

THE DIMAQ WORKSTATION PCBs

The DIMAQ workstation is made up of six printed circuit boards. Each of these boards performs specific functions in the formation and display of an ultrasound image cell. They are:

BOARD NAMES	ACRONYMS
Color Spectral Doppler Board	CSD
2-D mode / M-mode Acquisition & Preprocessing and System Data Memory Board	BDM
Reconstruction Display processor Board	RDP
Input / Output Video Board	IOV
Input / Output Expansion Board	IOE
Peripheral Interface Controller Board	PIC

**THEORY OF
OPERATION**

The DIMAQ workstation, as shown in the functional block diagram in Figure 5-3, performs the following major functions for normal 2-D mode imaging:

- Overall control of the Sequoia system
- Storage of ultrasound data for CINE functions
- Conversion of ultrasound scan format to video scan format
- Image enhancement and postprocessing
- Conversion to various video formats
- Alphanumeric and graphic display
- Interface to operator (front panel controls)
- Interface to peripheral recording devices (AEGIS system, VCR, Printers, etc.)

**ACQUISITION AND
PREPROCESSING**

Digital ultrasound video information is sent to the DIMAQ workstation from the Coherent Imageformer. In the DIMAQ workstation, the information is stored in the proper locations in the system data memory.

RECONSTRUCTION

From the system data memory, data is passed to the Reconstruction Display Processor (RDP). Here, 2-D and Color Doppler data are combined, M-mode or pulse Doppler data are stored to strip displays, and graphics and data block information are overlaid.

VIDEO CONVERSIONS

The data is then passed to the Input/Output Video board (IOV). Here the data is converted to a variety of video standards. Progressive RGB video is provided to the internal monitor. Also, interlaced composite and component video are derived from the progressive RGB. NTSC and PAL video standards are supported.

**DIMAQ
WORKSTATION
SUBSYSTEM
CONTROL**

The DIMAQ workstation provides overall control of the system, including user interface and high level control of other processors which, in turn, control subsystems. The main processor is the System Supervisory Processor (SSP) and is located on the Reconstruction Display Processor board (RDP).

**SYSTEM
SUPERVISORY
PROCESSOR**

This processor communicates with the BDM and CN via the system control bus. The SSP can also communicate with the PIC board via the Aux bus. This is used to configure the inputs and outputs from the PIC board, as well as to communicate with the SCSI devices on the system.

Whenever a key is pressed or a knob is adjusted, the SSP interprets this data and configures the system accordingly.

SCAN FORMATS

High-level information about the scanning mode is passed to the CN board. The CN, in turn, configures the Coherent Imageformer to scan in a mode that reflects the user's parameters.

The SSP also sends high-level configuration information to the BDM. The BDM is configured to capture data from the Coherent Imageformer, as appropriate for the scanning mode.

When a change is made to the scanning parameters, the corresponding graphic element on the monitor is changed to blue while the transition to the new format is performed. When the system is displaying data as selected by the new parameters, the graphic element reverts to white. This allows the user to know precisely when the system has completed reconfiguration of the scan format.

USER INTERFACE

The User Interface provides the interface between the user and the Sequoia system. One of the components of the User Interface is the Front Panel Processor (FPP) board. The FPP monitors the status of the user controls and, when changes occur, sends an interrupt to the System Supervisory Processor (SSP) located on the RDP board. The SSP then initiates the sequence of events needed to configure the Sequoia system as required.

The User Interface is designed in a modular fashion. The FPP board mates to the switch assembly via stand offs and hard connectors. The trackball, QWERTY (Alphanumeric keyboard), and DGC potentiometers assembly are connected with ribbon cables.

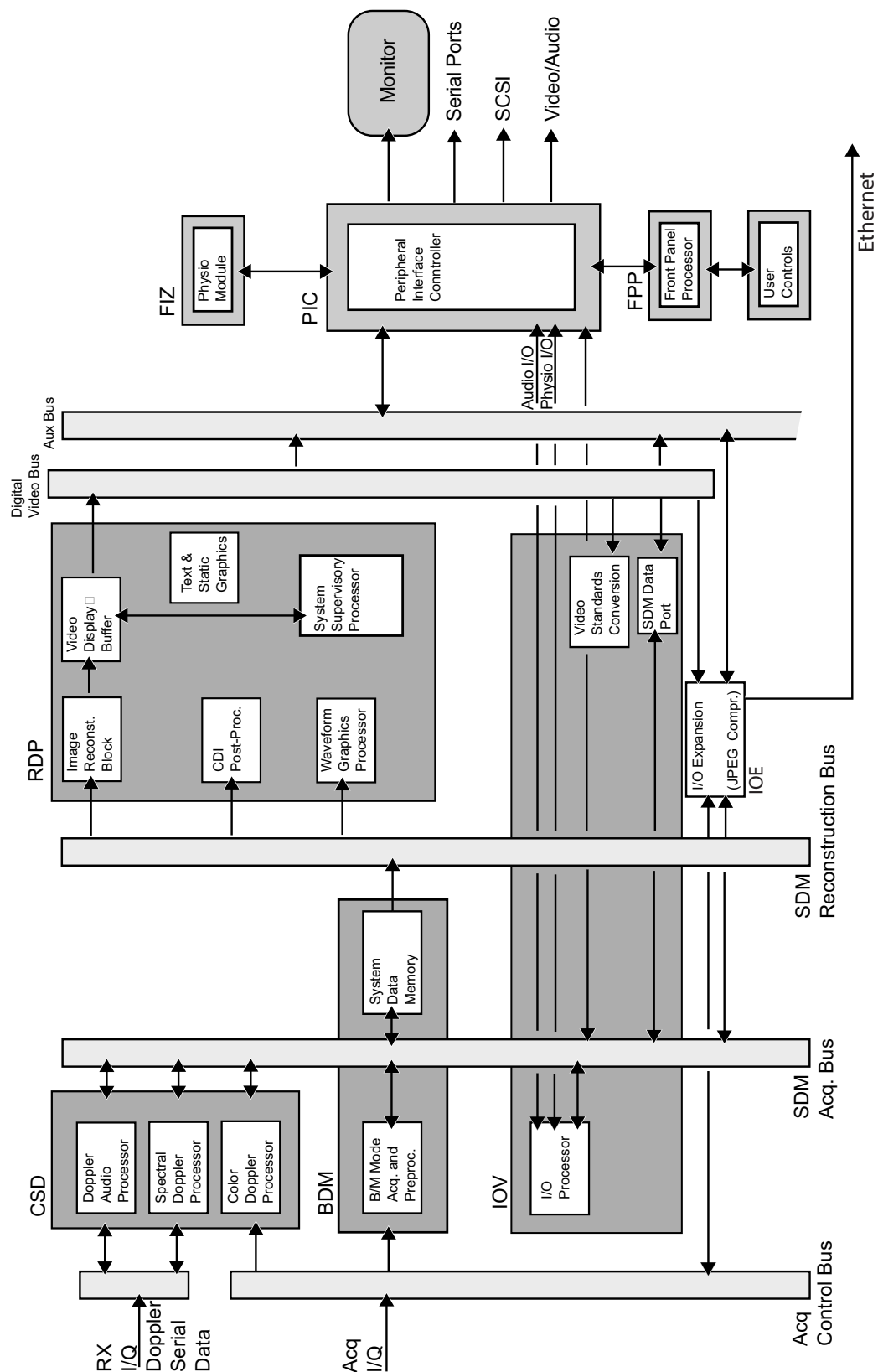


Figure 5-3 DIMAQ Workstation Block Diagram (IOE3)

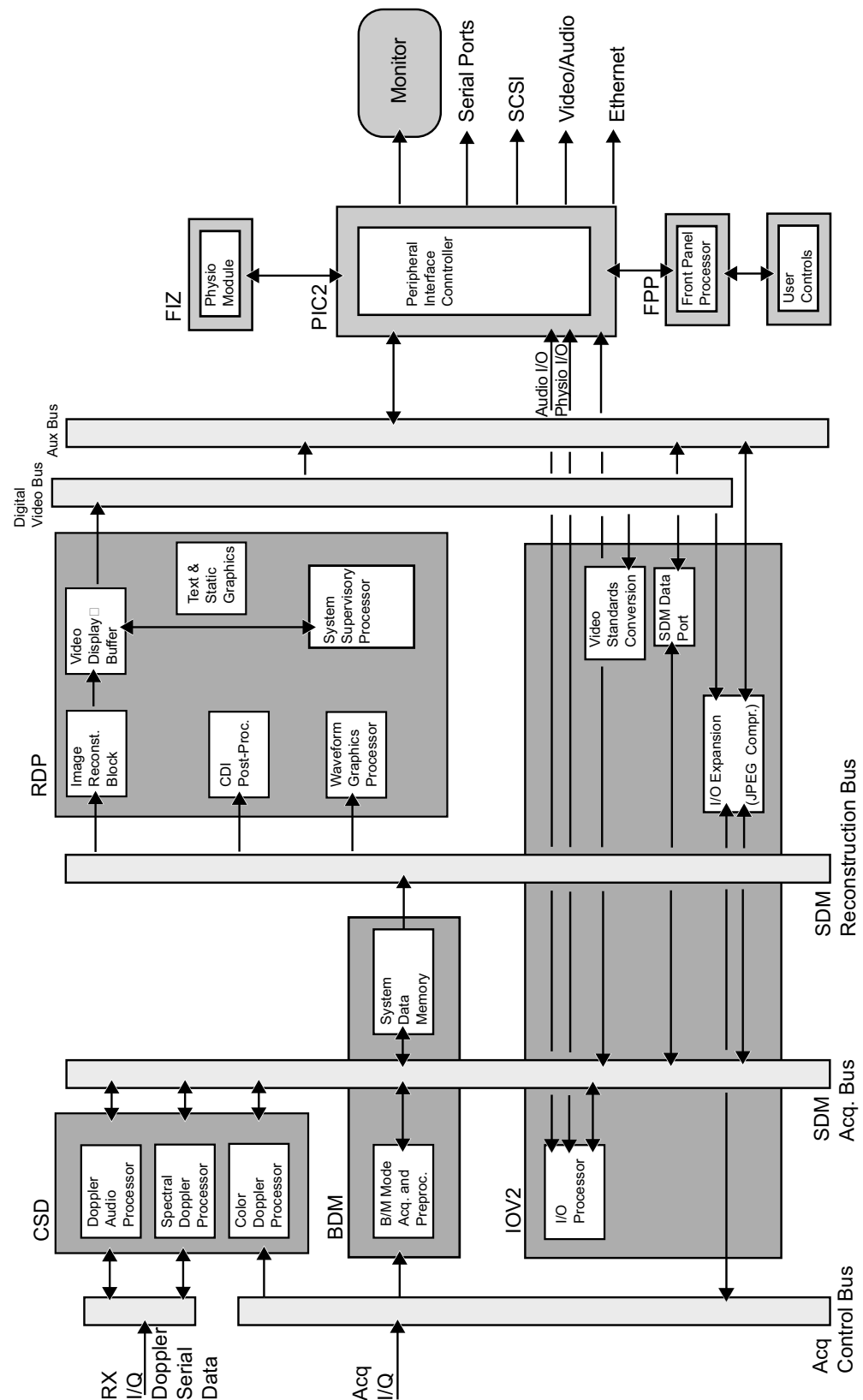


Figure 5-4 DIMAQ Workstation Block Diagram (IOV2/PIC2)

COLOR AND SPECTRAL DOPPLER BOARD

CSD1/2

Part Number CSD1 32082

Part Number CSD2 41462

Quantity 1

Power Supplies +5VDC, -5.7VDC

Signals In RX I/Q, Mode I/Q

Signals Out Spectral frequency data, spectral audio data,
Color Doppler data

FUNCTION

The CSD board processes the ultrasound echo data to extract spectral and color flow data. The CSD may be thought of as comprising three distinct functional subsections. These are spectral Doppler processing, audio Doppler processing, and Color Doppler processing.

SPECTRAL AND AUDIO PROCESSING

The spectral and audio sections of the CSD board receive RX I&Q data from the RX board directly. Echo clutter is removed from the signal. Then the data is converted from time domain to frequency domain. Both are then passed to the system data memory on the BDM for further processing and display.

COLOR DOPPLER PROCESSING

The Color Doppler data is received from the CN board as F-mode I&Q. The color flow parameters are extracted from the raw echo data and processed to derive a velocity estimate. The data is then passed to the system data memory on the BDM for further processing and display.

TROUBLESHOOTING HINTS

The CSD board is divided into three functional subsections, all processing data independently of each other. This provides important clues about possible failures.

When attempting to isolate a problem, first note the modality in which the problem occurs. If a manifestation of the problem occurs in all modalities then it is highly unlikely that CSD is responsible.

Problems likely to be related to the CSD board are those which appear in only one of the three modalities discussed earlier.

BDM BOARD

BDM1/2

Part Number BDM1 32062

Part Number BDM2 41472

Quantity 1

Power Supplies 5VDC

Signals In Acq. I/Q

Signals Out SDM bus

FUNCTION

The 2-D mode, M-mode, Spectral and System Data Memory board consists of two distinct functional components: the 2-D mode / M-mode Acquisition and Preprocessing (BAP) and System Data Memory (SDM). The BAP performs all detection and preprocessing operations for B/ M mode. The SDM is a high-bandwidth, high-capacity memory subsection for use in temporal processing, cine data storage, and buffering between acquisition and reconstruction functions.

SMM PROCESSOR

The System Memory Manager Processor (SMM) is responsible for management and allocation of the SDM memory, management, and synchronization of data to be displayed. Any access to SDM memory must have prior setup performed by the SMM.

RECONSTRUCTION AND DISPLAY PROCESSOR BOARD

RDP2/5

Part Number RDP2 38282

Part Number RDP5^A 53552

Quantity 1

Power Supplies +5VDC

Signals In 2-D, M Mode Spectral, VCR playback, and AEGIS system review data

Signals Out Setup parameters for the system, digital progressive RGB video

A. RDP5 is compatible with Sequoia 4.0 and higher.

FUNCTION

The RDP performs two primary functions. First, it has the System Supervisory processor located on it. Second, it takes the data for each mode from the BDM board and reconstructs an image.

The RDP board constantly receives data from the BDM board, overlays or mixes color data on the 2-D image, incorporates graphics, and displays M-mode and spectral strip data, etc. as required. When a frame of data has been completed, the data is read out to the IOV board.

SSP

The System Supervisory processor is, as the name suggests, responsible for managing the system at large. This includes processing user requests initiated at the user interface, setup of the Imageformer subsystem for the scanning mode selected, configuration of each of the PCBs to process the data required, etc. The SSP also handles communication with most of the Sequoia system and maintains system control bus accuracy.

TROUBLESHOOTING HINTS

The SSP performs many validations of its own functionality and its ability to communicate with other boards during the power on cycle. If the SSP fails to complete these self-tests, then the system will fail to boot.

The other function of RDP board is to read out the image, spectral, flow, VCR, or AEGIS system data from the BDM board, construct one image frame and pass the image format data to the IOV. Failure of this process may result in an image reconstruction problem or no update on the frame displayed.

INPUT/OUTPUT VIDEO BOARD

IOV1/2

Part Number IOV 33342

Part Number IOV2^A 41482

Quantity 1

Power Supplies +5VDC, +12VDC, -5.7VDC, ±12VDC

Signals In Video data from RDP, Audio data from BDM,
VCR playback data, AEGIS system review data

Signals Out Progressive RGB, S-VHS, VHS, voidable or NTSC
video formats, system audio.

A. IOV2 requires a PIC2 and eliminates the IOE3.

FUNCTION

The primary function of the IOV board is to provide conversion to and from various video format standards; e.g., NTSC, PAL; S-VHS and VHS. The video format used by the system monitor is a progressive, i.e., noninterlaced RGB video. This format is not compatible with most of the peripherals.

The IOV board supports other processes as well. These include processing audio data from BDM, and interfacing with the Physio/ECG board (FIZ).

The IOV2 also provides JPEG compression circuitry that was previously on the IOE3.

TROUBLESHOOTING HINTS

The IOV board is responsible for the video format conversion. If video is corrupted on one peripheral device but not on the other (e.g., video is OK on the display monitor but VCR recording is not correct and interface cable has been replaced), then it is likely that IOV is malfunctioning.

If the video is corrupted at all outputs than the RDP may be giving corrupted data to the IOV board, or the IOV itself is corrupting the video data.

Communication problems with FIZ board may be caused by the IOV board. If replacing the FIZ board doesn't correct the problem, try replacing the IOV board.

INPUT/ OUTPUT EXPANSION BOARD

IOE3

Part Number	42532
Quantity	1
Power Supplies	+5 VDC
Signals In	AEGIS system data, Ethernet communication
Signals Out	AEGIS system data, Ethernet communication

FUNCTION

The IOE board provides the hardware needed to interface to Ethernet networks. The Sequoia system uses 10BaseT Ethernet connection.

In addition, the IOE board has provisions for installing other circuit boards as daughter boards, to allow for future additions to the system's functionality.

Newer systems have the IOV2 and PIC2 boards, which eliminate the need for the IOE3.

TROUBLESHOOTING HINTS

The IOE board has sole responsibility for Ethernet communication of the Sequoia system to an Ethernet network. If the network setups and the interface to the network are OK then the IOE board may be replaced to correct the problem.

PERIPHERAL INTERFACE CONTROLLER BOARD

PIC1/2

Part Number PIC 30132

Part Number PIC2^A 43242

Quantity 1

Power Supplies +5 VDC, +12 VDC, -5.7 VDC, and ±12 VDC

Signals In All Video formats from IOV board, All playback video from the Peripheral devices, Audio from BDM, Audio from Peripherals.

Signals Out All Video formats to Peripheral devices, All playback video to the IOV board, Audio to Peripherals, speakers, headphones.

A. PIC2 requires the IOV2.

FUNCTION

The PIC board provides interconnections between the Sequoia system card cage and other assemblies or peripheral devices. These connections are made through the rear panel located at the rear of the Sequoia system.

Assemblies that are connected to the PIC board include the FPP board, FIZ board, Audio speakers, Monitor assembly, and the SCSI devices. Peripheral devices connected to the PIC board may include a VCR, Printers, Multi-Image camera, or the QV150.

The PIC board stores the system serial number in the BBRAM, and contains circuitry for reset, start-up and shutdown, etc.

The PIC board also has the capability to monitor many aspects of the system. These include power supply voltages, fuses, AC line voltage, and system temperature.

The PIC2 board provides the hardware needed to interface to Ethernet networks. The Sequoia system uses 10BaseT Ethernet connection.

TROUBLESHOOTING HINTS

The PIC board provides interconnections between various assemblies and peripherals. It is also an integral part of the power up / down sequences.

Generally, if a problem persists after replacing the assembly or the interface cabling, then try replacing the PIC board.

PHYSIO INTERFACE MODULE

FIZ

Part Number	35992
Quantity	1
Power Supplies	+5 VDC and ± 12 VDC
Signals In	Three lead ECG, Pulse, Phono, and Respiratory transducers, AUX Inputs.
Signals Out	ECG, Pulse, Phono, and Respiratory trace data, AUX outputs.

FUNCTION

The Physio Interface module is located above the card cage with the input/output jacks available at the left side of the system. The FIZ module provides a three-lead ECG input, pulse, phono, and respiratory input. Additionally, there are input ports available for auxiliary functions. Refer to the user manual for the supported auxiliary devices.

After configuration by the system supervisory processor on the RDP, based on the user controls, the FIZ module acquires data and passes it to the IOV over the same bus used for configuration.

TROUBLESHOOTING HINTS

The FIZ module contains multiple data channels, all of which are passed to the Sequoia system on a single bus. It is useful to know if the problem exists in one channel or all.

The user controls for the FIZ module are located on the User Interface. Check for a stuck or broken switch on the User Interface. Also verify operation of the gain control encoder for gain- or position-related problems.

FRONT PANEL PROCESSOR BOARD

FPP

Part Number	31642
Quantity	1
Power Supplies	+5 VDC, +12 VDC
Signals In	User Interface switch selections
Signals Out	User Interface changes to SSP on RDP board, LED annunciators, Two line LCD display.

FUNCTION

The PIC board provides the interface between the Sequoia system card cage and the user. The FPP has a processor on board that continually monitors the status of the user controls. When changes occur, the FPP sends an interrupt to the System Supervisory processor located on the RDP board. The SSP interrogates the user controls to find out which ones have been changed and initiates the sequence of events needed to configure the Sequoia system as required.

The User Interface is designed in a modular fashion. The FPP board mates to the switch assembly via standoffs and hard connectors. The trackball, alphanumeric keyboard, and the DGC potentiometers assembly are connected with ribbon cables. Two additional modules, which contain more controls, are connected to the FPP by ribbon cables.

All controls except the DGC pots are switches or digital encoders. The switches are decoded through the use of a switch grid, that is, each switch occupies the intersection of a pair of wires. The switches share each wire with other switches, but only one switch occupies each intersection.

TROUBLESHOOTING HINTS

The PIC board provides interconnections between various assemblies and peripherals. It is also an integral part of the Power on / off sequences.

Generally, if the problem persists after replacing the assembly or the interface cabling, try replacing the PIC board.

2-D/ M-MODE SIGNAL FLOW

TRANSMISSION

All Coherent Imageformer functions are controlled by the Controller board (CN). The CN passes parameter data to the TX boards on the Imageformer bus. In addition, configuration data is also passed to the MX and RX boards.

The high-voltage pulses from the TX board are passed to the Multiplexer board (MX). The MX board directs the transmit pulses to the appropriate transducer element, based upon the transducer(s) connected and the scan format used.

Each transducer consists of a piezoelectric-crystal element. A piezoelectric-crystal element changes spatially when a voltage is applied across it. On receiving a high-frequency electric wave, the piezoelectric-crystal element vibrates and creates a high-frequency ultrasound wave.

The ultrasound wave propagates into the tissue of the patient being scanned. Wherever there is a change in the acoustic impedance, such as at the interface between dissimilar tissues, a portion of the ultrasound wave is reflected. The magnitude of the reflected wave is a function of the difference in acoustic impedance between tissues at their interfaces.

RECEPTION

Ultrasound signal reception begins when the Coherent Imageformer fires an ultrasound wave. The digital ultrasound data, representing the instantaneous phase and amplitude values of the analog ultrasound signal, are loaded into the BDM board. Here, the data is preprocessed and loaded into the system data memory. Each frame of data is stored for CINE review and persistence functions. The number of frames that may be stored varies, depending upon the scan format used.

Persistence is implemented by the BDM board. It is achieved by modifying the current and previous data with a complex algorithm to remove temporally transient artifacts.

RECONSTRUCTION AND DISPLAY

The 2-D mode data stored in the BDM board is transferred to the RDP board, and mapped into the proper raster display format. The 2-D mode data is also combined with the graticules, static graphics, alphanumeric and waveform graphics that will ultimately appear on the monitor.

The digital RGB progressive video is passed to the Input/Output Video board (IOV). The IOV converts the digital RGB progressive video into an analog video.

The analog video is then converted into various video standards, e.g. NTSC and PAL video standards, interlaced composite or component (Y/C) video as well as interlaced RGB. These formats allow interfacing of peripheral recording devices on non-AEGIS systems.

Analog progressive RGB video is then passed to the Peripheral Interface Controller board (PIC). The PIC board provides buffering and connections for each of the supported peripheral devices as well as the system monitor. The progressive RGB is then passed to the system video monitor for display.

Figure 5-5 illustrates the 2-D mode/M-Mode signal flow.

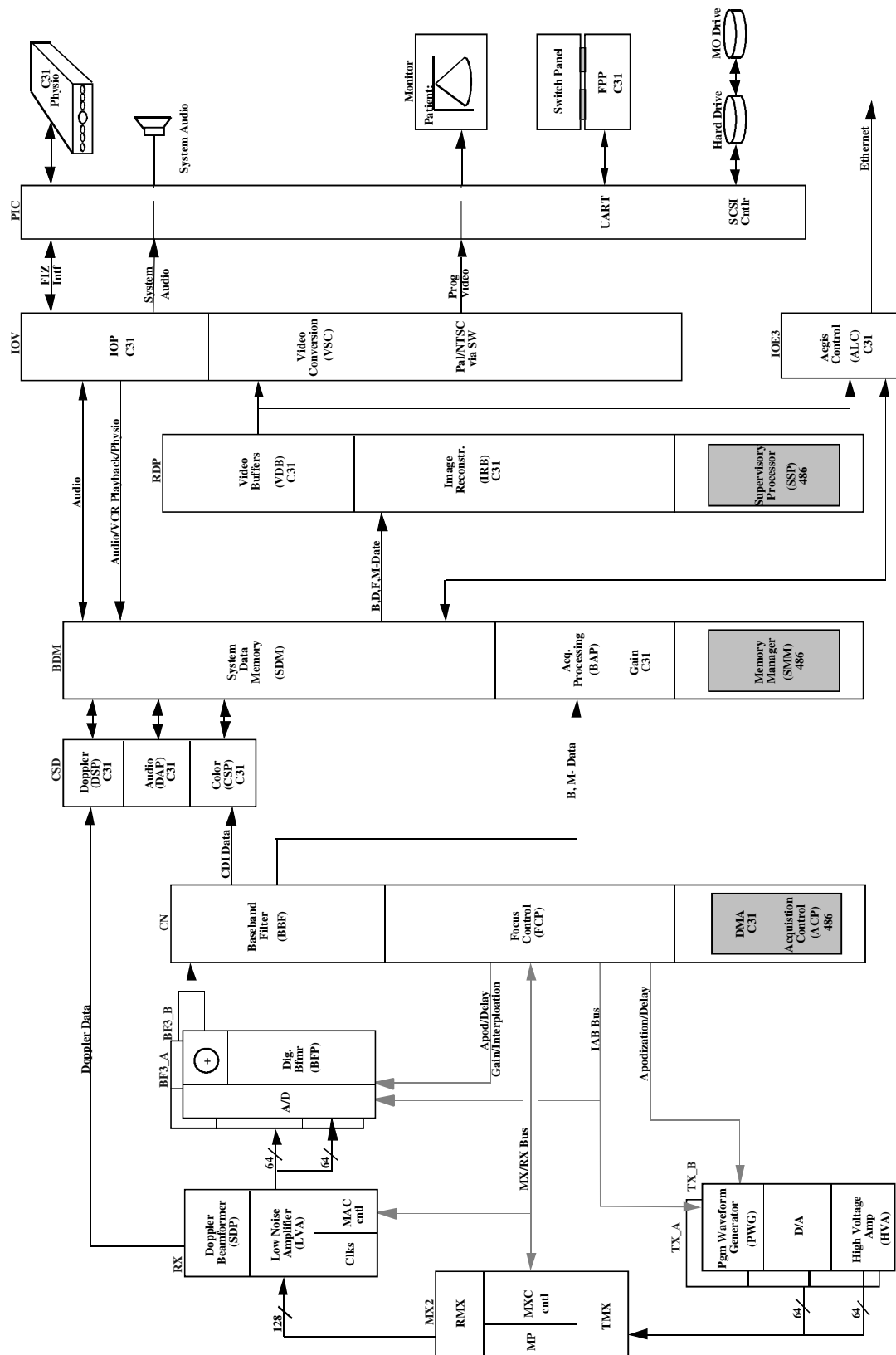


Figure 5-5 2-D Mode/M-Mode Signal Path

SOLO™ SPECTRAL DOPPLER SIGNAL FLOW

DOPPLER THEORY

Spectral Doppler is a way of processing echo data whereby the frequency shift of the echo data is mapped to a strip display, showing velocity distribution on one axis and time on the other.

The amount of shift is dependent upon the velocity of the reflector, while the direction of shift (e.g., higher or lower pitch) is dependent upon whether the reflector is moving towards or away from the transducer. The frequency received by the transducer will be shifted upwards if the target is moving towards the transducer and downwards if the target is moving away. Echo data shifted in frequency is called the Doppler signal. There is a major echo component that is not shifted in frequency, which comes from stationary tissue. This is known as clutter.

PULSE WAVE DOPPLER

Pulse Wave Spectral Doppler (PW Doppler) mode emits a pulse into the body and then monitors the echo data over a time interval that is set by the positioning of a range gate on the system monitor. By sampling the data at a specific area, clutter can be reduced dramatically.

NYQUIST LIMIT

If the sampling rate is not adequate for high-frequency Doppler shifts, artifactual lower frequency shifts are displayed. The requirement that the sampling rate must be at least twice the maximum frequency present in the Doppler signal is referred to as Nyquist criterion. One half of the pulse repetition frequency (PRF) is the Nyquist limit.

HIGH PRF

There is a high PRF mode that may be invoked, which results in a phantom range gate at a depth other than the area of interest. If there is no blood flow in the phantom area, this is an acceptable way of increasing the PRF.

CONTINUOUS WAVE DOPPLER

Continuous Wave Doppler (CW Doppler) mode emits a continuous ultrasound wave from a subset of the transducer elements. Other elements of the transducer continuously monitor the echo data. This allows many more samples than PW Doppler mode, but does not allow for ranging of the data. For this reason, the signal received has large amounts of clutter from the entire sample line. The Doppler signal is very small relative to this clutter. The Doppler signal must be separated from the clutter to be useful.

SOLO™ SPECTRAL DOPPLER

The Sequoia 512 system has a unique spectral Doppler architecture. It consists of a dedicated audio beamformer for spectral Doppler only. The Doppler beam formation is performed at audio frequencies because Doppler signal is an audio signal.

During spectral Doppler operation, the Doppler data is passed to the Spectral Doppler Preprocessor (SDP) subsystem, located on the RX board. The PW Doppler data is sampled only at the range gate. CW Doppler data is acquired from the entire sample line.

The Doppler data is then processed and the quadrature data (I&Q) derived. The I&Q data is then digitized and placed on the RX I/Q data path for processing and display by the DIMAQ workstation.

To achieve maximum performance, the spectral Doppler signal path in the Sequoia system is significantly different from the 2-D and Color Doppler signal paths. Refer to Figure 5-6 for a diagram of the signal path.

Spectral Doppler I&Q data is received at the Color Spectral Doppler board (CSD), directly from the Receiver board (RX) in the Imageformer. The BF board and CN board do not process the spectral echo data. The CSD provides the time domain to frequency domain conversion. Furthermore, the CSD generates the audio corresponding to the Doppler data received.

The spectral Doppler and audio data are then passed to the BDM board where they are stored to allow CINE and other temporal processing functions to be performed.

DISPLAY

The spectral Doppler data is passed to the RDP where it is merged with the spectral strip graphics as well as any other data to be displayed on the monitor. This data is then passed to the IOV board and then to the PIC board in a fashion similar to the 2-D mode data.

AUDIO

Audio data is passed directly from the BDM to the IOV board. It is not processed by the RDP. The audio data is then passed to the PIC board, which drives the speakers in the system, or is output to headphones or a video recorder.

COLOR DOPPLER SIGNAL FLOW

COLOR DOPPLER

Color Doppler imaging is a modality whereby the frequency shift of echo data is sampled at a large number of points within a defined area of the image. This area is defined using a CD Res box. The frequency shift samples are converted to a velocity estimation and mapped onto the monitor as a color, e.g., blue if the signal is frequency-shifted downward and red if the signal is frequency-shifted upward. This results in a graphic representation of blood flow or other motion.

SST™ COLOR DOPPLER

The Sequoia 512 system incorporates SST Color Doppler. This is enhanced by multiple Color Doppler beamformers and proprietary Color Doppler processing, to improve Sensitivity, Spatial resolution and Temporal resolution. The Color Spectral Doppler (CSD) board receives color I&Q signals from the Controller (CN) board. The CSD performs the majority of Color Doppler processing and uses memory located on the BDM to store intermediate results of this processing.

The color I&Q values represent the instantaneous data from a single temporal and spatial point. Processing velocity information for many points uses algorithms that require multiple samples of the same data point. For this reason, the results of color processing are a “time averaged” velocity.

The results of CSD processing are passed to the BDM board for storage. This is where the data is held for CINE review, as well as temporal persistence processing. The data is then passed to the RDP to be overlaid / mixed with the 2-D information. The color data is then passed to the IOV board and then to the PIC board in a fashion similar to the 2-D data.

Figure 5-6 illustrates the SST Color Doppler signal path.

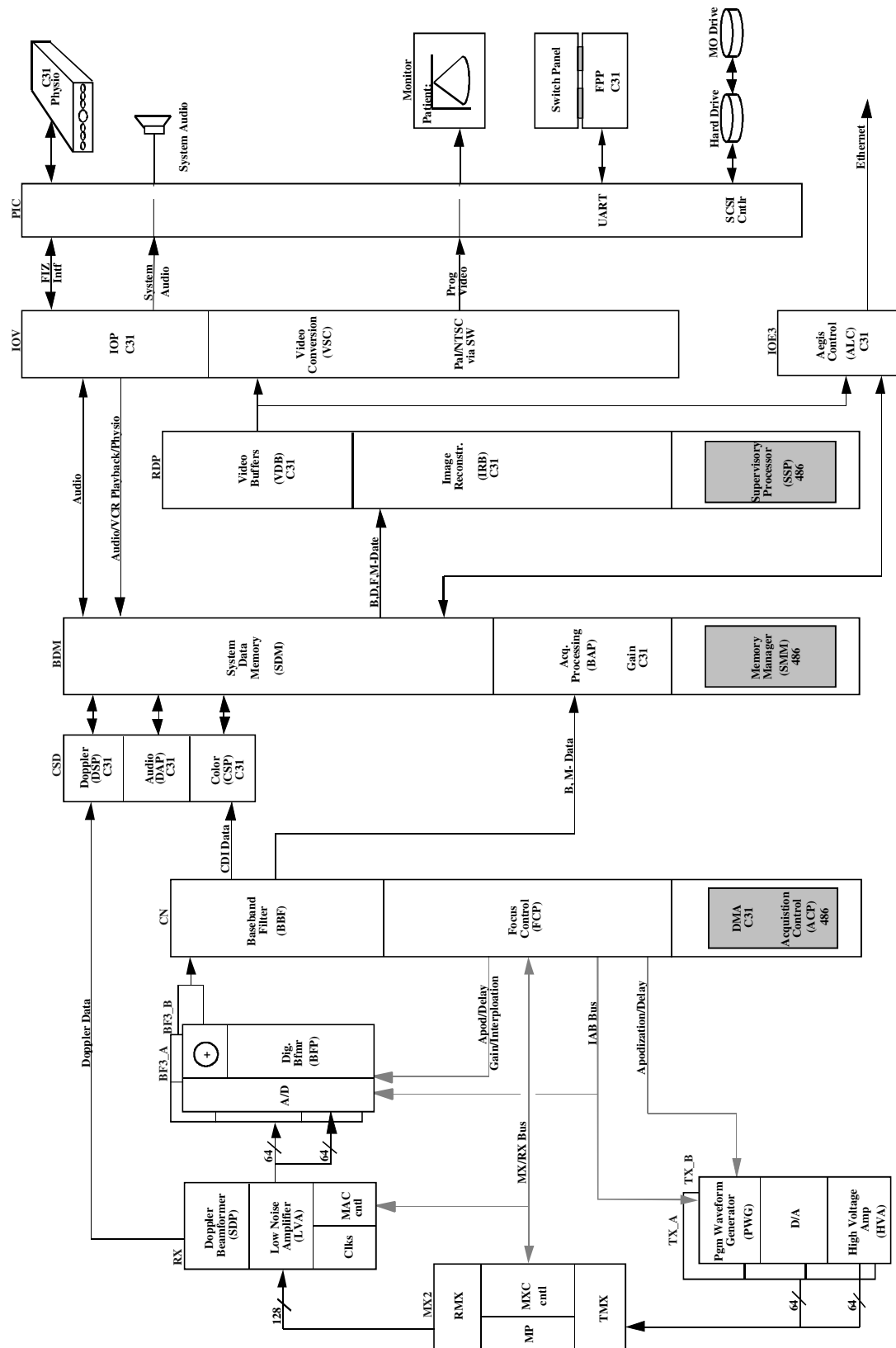


Figure 5-6 Color Doppler Signal Flow

ECG/PHYSIO SIGNAL FLOW

The Physio Interface allows an ECG, physiologic transducers and auxiliary signals to be displayed on the Sequoia system monitor. These signals may be used to trigger the 2-D mode image update when using Pulsed Doppler or M mode, or they may be used as a timebase when reviewing the CINE memory.

WARNING! The Physio Interface is not designed for use in conjunction with electrosurgery or diathermy equipment.

The Physio Interface board (FIZ) provides a three lead ECG input, a heart sounds input, a pulse input, and a respiration input. There are four additional inputs available for auxiliary functions. It is also possible to configure two of the auxiliary inputs with output signals under software control. Refer to the <Sequoia 512 User Manual for supported modes.

The Physio Interface board is located above the card cage with the input/output jacks available at the left side of the system.

Under software control, the RDP sends configuration data to the IOV board on the system control bus. The data is transferred from the IOV board to the FIZ board on a dedicated bus.

After configuration, the FIZ board acquires data and passes this data to the IOV over the same bus used for configuration. The IOV routes this data to the BDM where it is stored for CINE review. The physio data is then passed to the RDP, where the graphic display is overlaid on the video image.

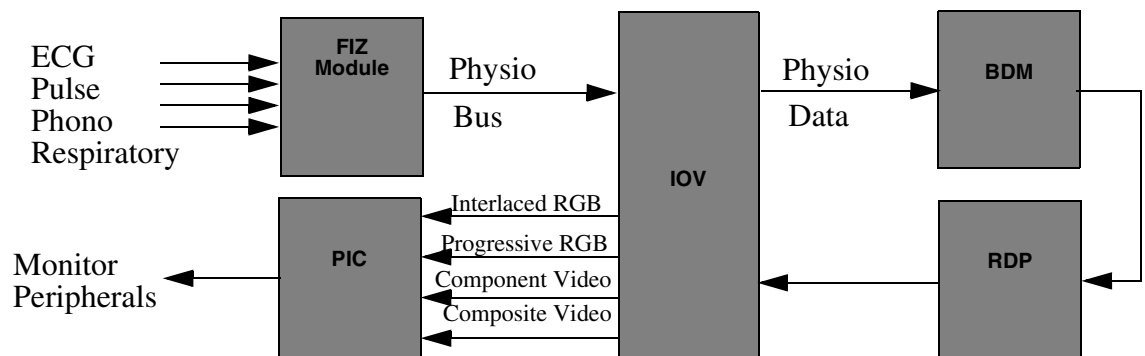


Figure 5-7 ECG/ Physio Signal Path

DIMAQ SYSTEM STORE AND REVIEW

ACQUISITION

The Sequoia systems supports the acquisition of both static and dynamic clips. For acquisition, the DIMAQ workstation receives video data from the IOV board in interlaced RGB format, performs color space conversion to Y, R-Y, and B-Y (YUV), prior to JPEG compression. The compressed images are stored in the SDM on the BDM board, from which they can be decompressed for review, or transferred out for storage on an MO drive or hard drive.

REVIEW

For review, the IOE board in the DIMAQ workstation provides the ability to decompress the video acquired in JPEG format, and store the **Run Length Encoded** (RLE) YUV raster format data in SDM on BDM board. This allows reconstruction by RDP board, and subsequent conversion to video by IOV board, for display on the monitor via the PIC board.

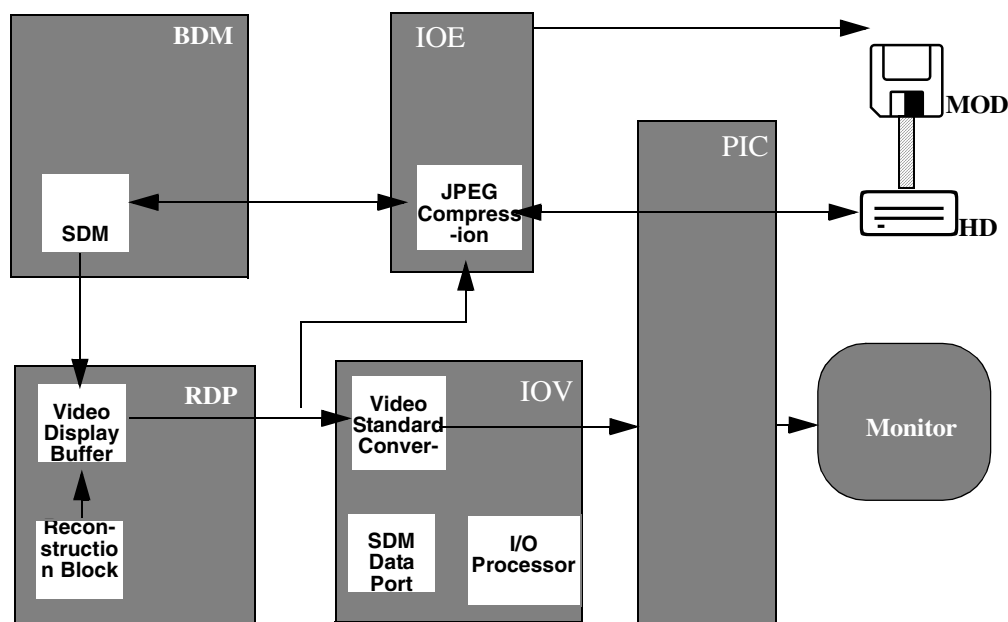


Figure 5-8 DIMAQ System Signal Flow (Systems with IOE3 board)

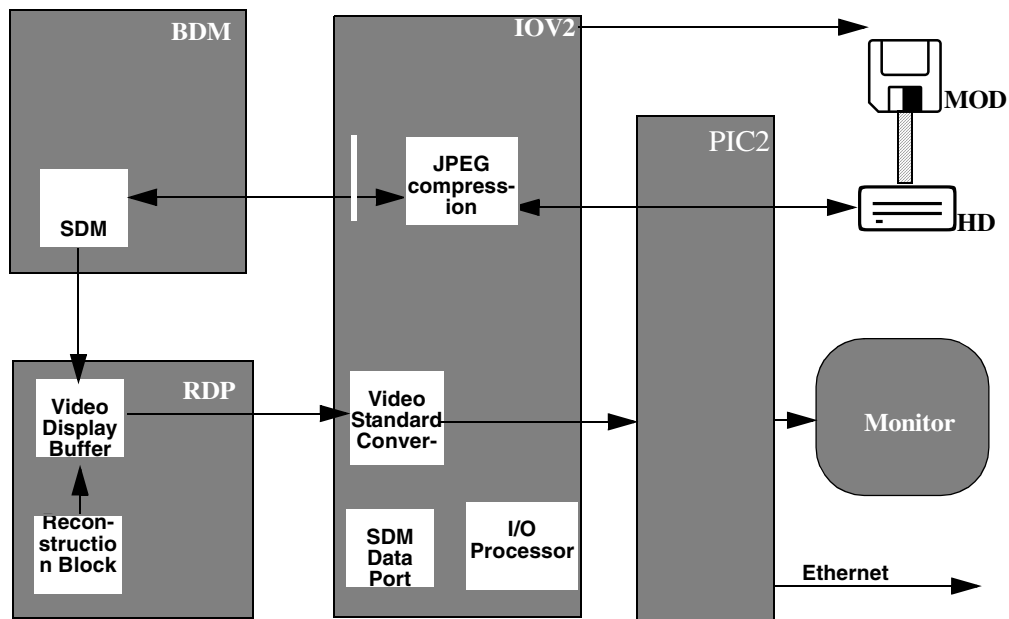


Figure 5-9 DIMAQ System Signal FLOW (systems with IOV2/PIC2)

VCR PLAYBACK

ACQUISITION

The Video Standard Converter (VSC) on IOV board receives the external video input from VCR via the PIC board and converts it to digital format for storage into SDM on BDM board.

VCR autocalibration data is digitized as part of video input process and captured by this block.

PLAYBACK

The video data stored in the BDM board is transferred to the RDP board, and mapped into the proper raster display format. The digital RGB progressive video is passed to the Input/Output Video board (IOV). The IOV converts the digital RGB progressive video into an analog video.

The analog video is then converted into various video standards. Analog progressive RGB video is then passed to the Peripheral Interface Controller board (PIC). The PIC board provides buffering and the progressive RGB is then passed to the system video monitor for display.

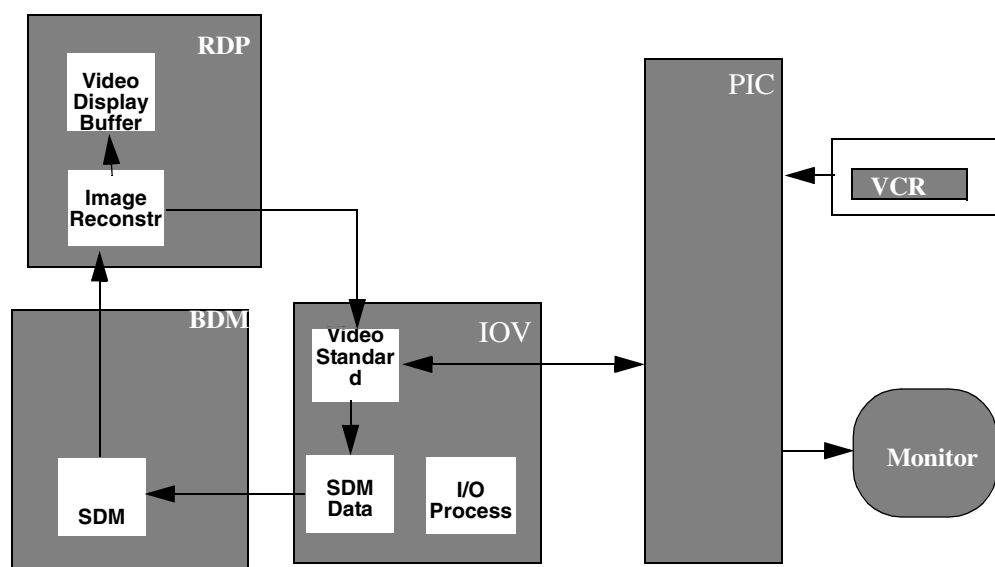


Figure 5-10 Video Playback Signal Path

WORKSHEET: SYSTEM ARCHITECTURE

- 1 Describe three hardware differences between the Sequoia 512 and Sequoia C256 systems?
- 2 How many TX boards are there on a Sequoia C256 system?
- 3 Where is the ACP processor located?
- 4 Where is preprocessing done for spectral Doppler?
- 5 Where is the Master Clock located?
- 6 What is the SSP? Where is it located?
- 7 Do Sequoia systems support interlaced video or progressive?
- 8 Where are graphics overlaid onto the image?
- 9 Which board generates the Sequoia system tree splash screen?

- 10 Write down the names of the SCSI devices in a Sequoia system.
- 11 Where does the OS (Operating System Software) reside: RDP or HD?
- 12 Where is compression / decompression done for AEGIS system images?
- 13 Which board supports the Ethernet interface?
- 14 What is RI? Describe its function.
- 15 Where does the TX board get high voltage for transmission?
- 16 Does CSD support spectral Doppler?
- 17 Where is Persistence performed for 2-D mode?

18 Which board stores CINE?

19 Which board supports hardware monitoring?

